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OFFICE OF
PREVENTION, PESTICIDES
AND TOXIC SUBSTANCES

Memorandum

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SUBJECT: Initial Biological and Economic Benefits Assessment for Azinphos-methyl on Brussels Sprouts

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SUMMARY

Based on available published information and personal communications with crop experts, BEAD believes that the impacts resulting from extending the restricted entry intervals for azinphos-methyl on Brussels sprouts will be minor. The California State Recommendations and the Crop Profiles recommend azinphos-methyl only for the cabbage root maggot. However, according to experts in the field many growers are using azinphos-methyl on Brussels sprouts for cabbage aphid. There are many effective alternatives for aphids listed in the Crop Profiles. BEAD believes that the impacts resulting from extending the restricted entry intervals for azinphos-methyl on Brussels sprouts will be minor, because growers will switch to the recommended alternative insecticides.

BACKGROUND

Brussels sprouts are a cool season crop, belonging to the cabbage family, and are closely related to cauliflower, broccoli, kale, and collards. Like cauliflower, Brussels sprouts thrive best in a cool humid climate, thus commercial production of this crop is concentrated in the "fog-belt" of California with limited production in the Long Island, New York area. The edible portion of this crop is the bud or small cabbage-like head which grows in the axils of each leaf.

Brussels sprouts are germinated in greenhouses, then transplanted as seedlings to the field. Fields are irrigated through overhead sprinklers. This type of irrigation delivers pre-plant herbicides and fertilizers into the soil and stabilizes the planting beds until root systems become established. Irrigation continues at weekly intervals in sandy soil, or two to three week intervals in heavier soil.

Development of "one harvest" varieties in the 1960s led to a radical change in Brussels sprouts growing practices. Rather than being harvested continuously, the plants are topped (i.e., the apical mainstem is pinched or removed) when the sprouts at the bottom of the stalk begin to mature. This procedure stops the growth of the plants and forces the remaining sprouts to mature uniformly, allowing the field to be mechanically harvested in a single pass, 50 to 60 days after topping. This harvesting method has greatly reduced labor requirements in what previously had been a labor intensive crop production system. These newer machine-harvested varieties mature in 130 to 150 days after transplanting and are generally grown for the October-through-November market. Rowena, a variety that matures 180 to 195 days after transplanting, is a popular variety grown for the November-through-January market .

Although the majority of fields are mechanically harvested, approximately 18% are hand picked for the fresh market. A widely grown variety for this market is Oliver, which matures relatively quickly at 90 days after transplanting. Much of the fresh market fields are hand picked four to five times over a period of eight to ten weeks, as the sprouts mature from bottom to top.

Production

Commercial Brussels sprouts production is located primarily in California. The 1997 Census of Agriculture lists acreage in other states, which account for less than 4% of the harvested acres. Total California Brussels sprouts production was 42 million pounds in 1999, and was valued at $14.7 million according to the USDA's National Agricultural Statistics Service.

Brussels sprouts: Area, Production, and Value of Production in California for 1990:

- Harvested Acreage (Acres): 3,185
- Production (million pounds): 42
- Percent of U.S. Production: >99%
- Value of Production ($1000): $14,726

(Source: USDA/NASS Agricultural Statistics 2000. California accounts for 96% of the harvested acres of Brussels sprouts as reported in the 1997 Census of Agriculture. Other states listed as containing Brussels sprouts acreage are: CT, KY, ME, MD, MA, MI, NH, NJ, NY, PA, and VT. NY is the largest with 63 harvested acres reported.)

Of the 42 million pounds of Brussels sprouts produced in California, 18% (7.56 million pounds) are directed to the fresh market. Nearly all of the remaining 82% (34.44 million pounds) are directed to the processed (frozen) food end use market. California's 1999 fresh market Brussels sprouts were valued at $2,098,000 and the processed Brussels sprouts were valued at $6,888,000. (Source: USDA/NASS Agricultural statistics 2000. Note: Production data for 1999 appears to reflect recent patterns in production. About 18% of Brussels sprouts are directed to the fresh market. See the *'Proposed Mitigation for Azinphos-methyl' section of this report.* Value of Production data was provided by Mia Monarch, Santa Cruz County Agricultural Commissioner's Office, conversation with David Donaldson 1 May 2001.)

USE OF AZINPHOS-METHYL ON BRUSSELS SPROUTS

An average of 35% of the California Brussels sprouts acreage is treated with azinphos-methyl per year, and about 902 pounds of azinphos-methyl are applied. The average number of applications of azinphos-methyl per year in California is 1.08 with an application rate of 0.75 pounds per acre per application.

Usage of azinphos-methyl on Brussels sprouts (for the Fresh and Processed Market) in California:

- Percent of Crop Treated 35%
- Base Acres Treated [1] 1115
- Total Pounds Applied 902 lbs
- Average Number of Applications 1.08/year
- Average Application Rate 0.75 lbs/acre

(Source: Data is a two year average of California Department of Pesticide Regulation Pesticide Use Data from 1998 and 1999.[1] Base acres treated calculated using percent of crop treated estimates against bearing acreage.)

Target Pests

Azinphos-methyl is primarily used to control aphids after imidacloprid, applied at plant, has lost its effectiveness, about 80 days after planting. The most troublesome species of aphids is the cabbage aphid, *Brevicoryne brassicae*, followed by the green peach aphid, *Myzus persicae*.

Adult cabbage aphid females asexually produce live offspring, and populations can increase to damaging levels very rapidly. As many as 21 generations per year can occur in warmer climates, such as areas in California where Brussels sprouts are grown. When population levels are high, winged forms of the aphids are produced, which then disperse and infest new plants.

The cabbage aphid is a sap-sucking insect that feeds by inserting a stylet into the plant's vascular system and sucking cell sap, causing the leaves to become curled and crinkled. If untreated, moderate levels of infestation will cause yellowing and stunted plant growth, reducing quality and yield. The presence of aphids on the commodity at harvest constitutes adulterated, unmarketable product, and damage from larger infestations can result in death of the plant. Infestations of cabbage aphid threaten marketable yield losses of 100% if not treated.

A secondary insect pest for which azinphos-methyl is used is the larval form of the cabbage root maggot, *Delia radicum.* Larvae form dense colonies on the feeder and taproot of Brussels sprouts. Several hundred larvae can be found on one plant. They feed for 3 weeks, then pupate in the soil or on the roots of the host plant for 2 to 3 weeks before emerging as adults. Most years there are 2 to 3 generations, but under favorable weather conditions there can be more generations per season.

Cabbage root maggots can cause plant stunting, yellowing, and wilting. Young seedlings are more susceptible to permanent damage than mature plants. Additionally, injury from root maggots provides an entry point for pathogens.

Other minor pests for which azinphos-methyl is used are lepidopteran larvae. These primarily include cabbage looper, imported cabbageworm, and beet armyworm. Cabbage looper feeds on the leaves, occasionally damaging seedlings, but they inflict the most economic damage directly to the sprout heads. Aside from the damage caused to the sprouts from chewing, cabbage loopers deposit fecal matter and their exuviae remains on the sprouts, rendering the commodity adulterated and unmarketable. Larvae of the imported cabbageworm feed for two to three weeks on the leaves and bore into the sprout heads. As with the cabbage looper, economic damage from imported cabbageworm is the result of direct feeding or contamination of the heads. The coastal areas are subject to infestations of armyworm from June through October. Beet armyworm is most threatening to young foliage and buds, and economic damage results primarily from stunted plant growth as a result of feeding damage.

ALTERNATIVE PEST CONTROL METHODS:

Aphids

It is important to prevent the establishment of cabbage aphid in Brussels sprouts during the early stages of plant growth. This aphid is a difficult pest to control once the canopy has developed and the sprouts have formed. These are the chemicals recommended by the state and in the crop profiles.

- Chlorpyrifos is the standard for controlling aphids in Brussels sprouts. It has been called the "linchpin" of commercial Brussels sprouts production, because pest control programs for this vegetable revolve around it. It is faster acting than oxydemeton-methyl, dimethoate, and imidacloprid.
- Dimethoate is a systemic insecticide usually mixed with chlorpyrifos and applied two times per season. This helps to prevent pest resistance to chlorpyrifos, and increases aphicidal efficacy during periods of high infestation. Dimethoate is also effective against green peach aphid.
- Oxydemeton-methyl was the third most commonly used material in the late 1990s, but the label prohibits ground spray applications of this product within 100 feet of an occupied building, or within 150 feet for aerial applications. Because of this restriction, imidacloprid is usually substituted for oxydemeton-methyl for aphid control in these areas.
- Diazinon is usually applied when diamondback moths are also present in the field. With the registration of spinosad for diamondback moth, usage of diazinon appears to be declining.
- Imidacloprid is a systemic, chloronicotinyl insecticide with foliar and soil uses. Previous low use of this chemical may be explained by high product cost, coupled with poor efficacy as a foliar application. Label states "Provado 1.6 Flowable will not knock down heavy aphid or whitefly populations." The soil treatment is efficacious for approximately 80 days after application. This is adequate control for early maturing varieties, but most other varieties require a foliar application mid- to late-season.
- Disulfoton is being replaced to some extent by imidacloprid for control of cabbage aphid and green peach aphid.
- Endosulfan is a rotational material with spinosad for diamondback moth control, although it is applied to control aphids.
- Malathion is not very effective in aphid control.

Alternative Chemical Controls:

- Naled– although registered for aphid on Brussels sprouts, the label rate indicates its use is appropriate for looper control, which may not be sufficient to control aphids.
- Soap– due to the attractiveness of Brussels sprouts to aphid and the morphology of the plant, cabbage aphid is difficult to control with soaps. Numerous applications, at weekly intervals in some cases, are necessary to reduce aphid populations. Even with this usage regime, control of cabbage aphid on Brussels sprouts with insecticidal soap is extremely difficult.

Biological Controls:

- *Diaertiella rapae*, a parasite, can help aid in the control of aphid, but cannot control large infestations. Aphids are also preyed upon by lady beetles, green lacewing and syrphid larvae. However, once the aphid gets inside the sprout, predators have difficulty reaching them, and their effectiveness as biological control agents is minimized.

Cultural Control Practices:

- Brussels sprouts and other cole crops are often surrounded by non-crop areas that are not managed and provide alternate hosts for cabbage aphid, especially wild mustards that are genetically similar to cole crops. Cabbage aphid can infest Brussels sprouts and wild mustard concurrently, and therefore adjacent weedy areas must be kept clean of this source of aphid colonization. Tillage and herbicides can be used in an effective field sanitation program to minimize aphid pressures. However, this conflicts with no-till and low-till situations in some watershed areas.

Cabbage Root Maggot

- Chlorpyrifos is the most efficacious insecticide for the control of cabbage root maggot in Brussels sprouts.
- Diazinon is registered for use against cabbage maggot, but it is not as efficacious as chlorpyrifos.
- Fonofos can be used as a preplant insecticide. However, the manufacturer has discontinued the product because of low profitability. Existing supplies can be used until December 31, 2001, at which time registration will expire and the manufacturer will buy back remaining product.

Lepidoptera Larvae

- The Lepidoptera larvae may be controlled by permethrin, methomyl, naled, spinosad, carbaryl, cypermethrin, and lambda-cyhalothrin. Some of these chemicals only work on the early instars of beet armyworm.

Biological Controls:

- There are no known effective biological controls for cabbage maggot. There are several predators and parasitoids that target the Lepidoptera larvae.

Cultural Control Practices:

- Since maggots require crop residue and high organic matter in soil to persist between crops, fallowing fields for even short periods can reduce maggot incidence significantly. This is particularly true if soil is allowed to dry between plantings. Deep plowing and cultivation to bury organic matter deep underground can also reduce maggot pressure. Any other method of cultivation or crop management directed at avoidance of organic matter in the seed row, can reduce maggot incidence and damage to the young crop.
- There are no known cultural practices for control of the various lepidopteran larvae.

Current Insecticide Use

Table 1. Leading Insecticides used in California to control aphids or cabbage root maggots in Brussels Sprouts.

Brussels Sprout Insecticides in Order if Importance (Based on Percent of California Crop Treated in 1999)	% Crop Treated
Chlorpyrifos	94%
Diazinon	77%
Oxydemeton-Methyl	66%
Imidacloprid	60%
Dimethoate	55%
Azinphos-Methyl	29%
Endosulfan	8%
Disulfoton	7%
Malathion	5%
Acephate	< 1%
Pyrethrins	< 1%

(Source: California Department of Pesticide Regulation Pesticide Use Data from 1999.)

RESTRICTED ENTRY INTERVALS

The current label REIs for azinphos-methyl use on *Brassica* is 4 days (5 days in areas with less than 25 inches of rain per year). Please refer to the occupational and residential human health risk assessment on the Agency's website (http://www.epa.gov/pesticides/op) for information concerning the worker risks associated with the restricted entry intervals for this chemical.

IMPACTS RELATED TO OCCUPATIONAL RISK MITIGATION

Chlorpyrifos is the chemical of choice for aphid and cabbage root maggot control in Brussels sprouts. However, some growers choose to use azinphos-methyl. Azinphos-methyl may be applied early in the season if imidacloprid is not applied at transplant. Immature plants of Brussels sprouts need to be scouted weekly. Irrigation needs to be done on a weekly basis on sandy soils and up to every three weeks on loamy soils. Increasing the REI should not interfere with Brussels sprouts transplant thinning, as they are planted at the proper density. However, weeding is critical when the transplants are becoming established. Weeds will out compete seedlings for sunlight, water, and nutrients, and therefore must be controlled quickly when the Brussels sprouts are young. An extended REI would interfere with this activity.

In more mature Brussels sprouts, extending the REI of azinphos-methyl could interfere with pruning, topping, and hand-harvesting activities. Its use would be limited to the longer maturing varieties, and would have to be too early season to be of any use to the grower. Restricting hand-harvesting, which is done over a 8-10 week period, would impact the fresh market production for crops treated with azinphos-methyl, about 18% of Brussels sprouts production.

If the REIs were significantly lengthened, critical scouting, irrigation, weeding, pruning/topping, and hand-harvesting activities would be effectively precluded. BEAD believes that growers would then most likely choose to switch from azinphos-methyl to alternative chemical control methods, as opposed to continuing to use azinphos-methyl and abandoning potentially critical activities until the REI expires. This being the worst case scenario, would in effect end the use of azinphos-methyl in Brussels sprouts. BEAD believes, however, that under these circumstances Brussels sprouts growers will replace the use of azinphos-methyl with one of several available efficacious alternatives. (See the above section covering the alternative chemical controls to azinphos-methyl.)

As a result, BEAD does not expect there to be any grower, regional, or national level impacts from extending the restricted entry intervals for azinphos-methyl on Brussels sprouts, because BEAD believes growers will obtain the same level of control with the alternatives as they currently do with azinphos-methyl. There are several effective chemical, biological, and cultural pest control alternatives for the key insect pests in this crop. Additionally, most alternative chemical controls are expected to be comparably priced.

CHARACTERIZATION OF IMPACTS ON CROP

Azinphos-methyl is primarily used by the industry to control aphids after imidacloprid loses its effectiveness, although, chlorpyrifos is the insecticide of choice for aphids. Additionally there are several alternative compounds which may be used to control aphids. Chlorpyifos and diazinon are the only alternatives for the cabbage root maggot.

BEAD believes that the impacts resulting from extending the restricted entry intervals for azinphos-methyl on Brussels sprouts will be minor, because growers will switch to alternative insecticides which are comparably priced and do not appear to pose other practical issues.

RESOURCES

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